Floyds Fork Nutrient TMDL Targets

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Presentation Outline

I. **What Is Aquatic Life Use?**
II. **How Do Excessive Nutrients Impact the Aquatic Life Use?**
III. **How Is Aquatic Life Use Support Determined?**
IV. **Interpreting and Translating Narrative Standards to Develop Quantitative Targets**
V. **Floyds Fork Nutrient TMDL Targets**
VI. **Monitoring Strategy for TMDL Target Validation**

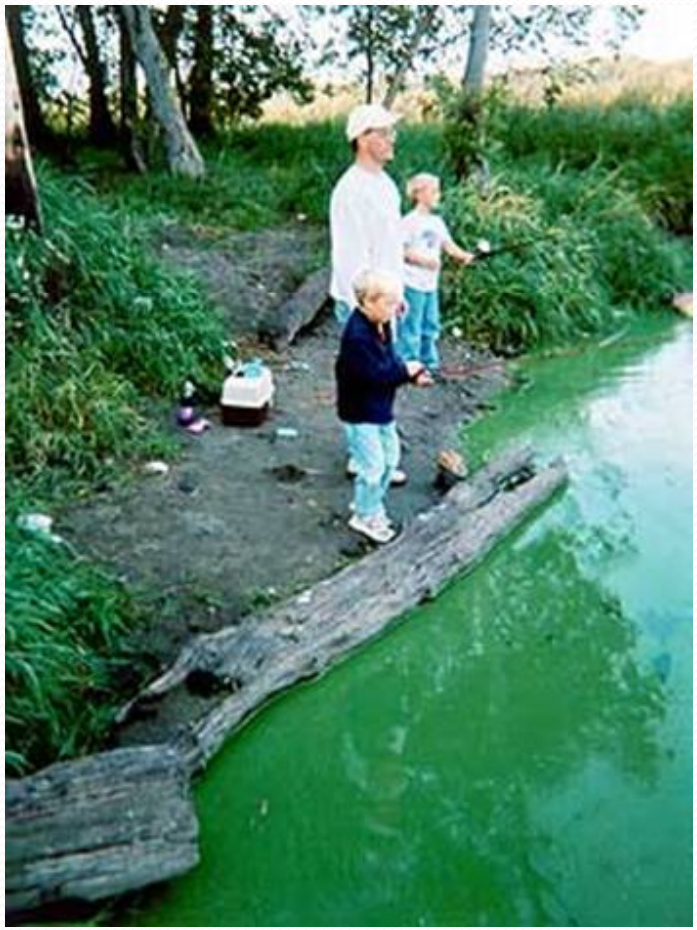
I. What Is Aquatic Life Use?

- Water quality must be good enough to maintain and propagate healthy populations of native aquatic species (Clean Water Act interim goal).
- If healthy populations of native species are maintained, then the waterbody supports the aquatic life use.
- If healthy populations of native species are not maintained, then the waterbody does not support the aquatic life use and may be considered impaired.

II. How Do Excessive Nutrients Impact the Aquatic Life Use?

- Direct effects – excess algal and plant growth
  - aesthetics
  - taste and odor problems
  - altered habitat for aquatic life
    - smothering of surfaces needed for attachment or reproduction
    - turbid conditions from dense planktonic bloom
  - physiological stress to aquatic organisms from low and/or widely fluctuating dissolved oxygen and pH
  - blue-green bacterial blooms with possible microcystin release (hepatotoxin that can kill livestock, dogs)

II. Excess nutrients in streams



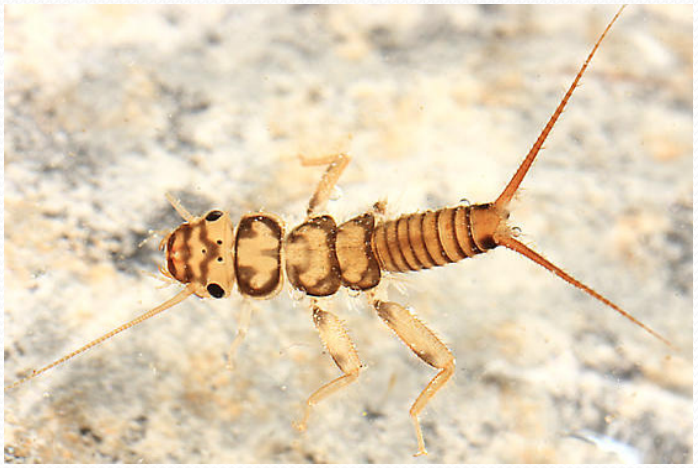
II. How Do Excessive Nutrients Impact the Aquatic Life Use?

- Indirect effects on aquatic life
  - reduced biodiversity
  - loss of sensitive species
  - increased dominance of tolerant and/or nuisance species
  - reduced capacity for ecosystem processing of materials
  - reduced ecosystem resilience to short and long term environmental change

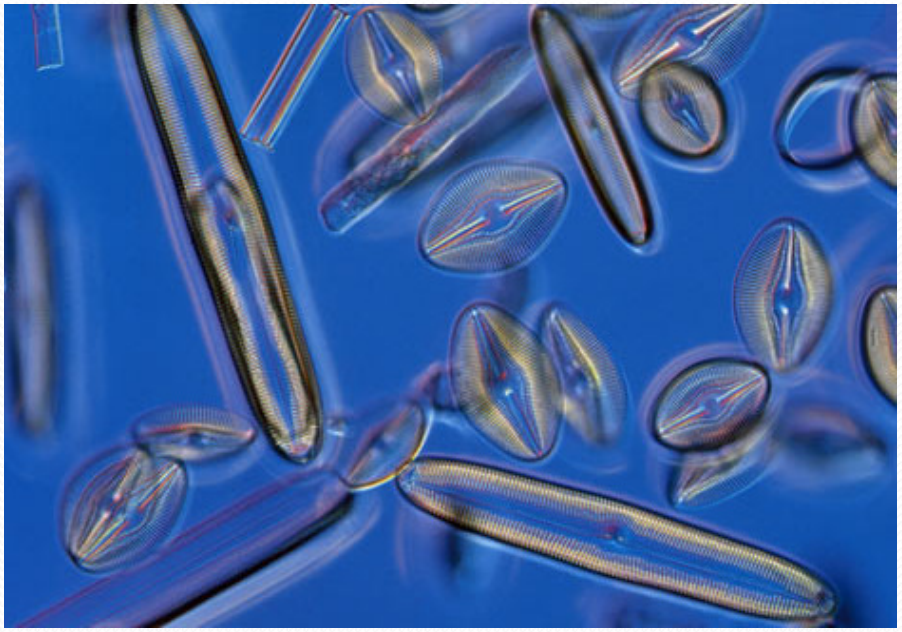
I. How is Aquatic Life Use Support Determined?

- **Biological assessment of indicator communities**, such as fish, macroinvertebrates and diatoms and
- **Water Quality Standards (Numeric and Narrative)** for specific chemical and physical parameters

Indicator Communities for Assessing Aquatic Life



Macroinvertebrates



Diatoms

Fish

Water Quality Standards Related to Excessive Nutrients

401 KAR 10:31. Surface water standards.

Section 1. Nutrient Limits. In lakes and reservoirs and their tributaries, and other surface waters where **eutrophication problems** may exist, nitrogen, phosphorus, carbon, and contributing trace element discharges shall be limited…

Water Quality Standards Related to Excessive Nutrients

Section 2. Minimum Criteria Applicable to All Surface Waters.

(1) …Surface waters shall not be aesthetically or otherwise degraded by substances that

…

(c) **Produce objectionable color, odor, taste, or turbidity**;

(d) **Injure,** are chronically or acutely toxic to or **produce adverse physiological or behavioral responses in humans, animals, fish, and other aquatic life;**

(e) **Produce undesirable aquatic life or result in the dominance of nuisance species;**

Water Quality Standards Related to Excessive Nutrients

Section 4. Aquatic Life.

(1) Warm water aquatic habitat. The following parameters and associated criteria shall apply for the protection of productive warm water aquatic communities, fowl, animal wildlife, arboreous growth, agricultural, and industrial uses:

…

(b) **pH shall not be less than** six and zero-tenths **(6.0) nor more than** nine and zero-tenths **(9.0)** and shall not **fluctuate** more than one and zero-tenths **(1.0)** pH unit over a period of twenty-four **(24) hours;**

Water Quality Standards Related to Excessive Nutrients

Section 4. Aquatic Life (continued)

…

(e) Dissolved oxygen.

1.a. Dissolved oxygen shall be maintained at a **minimum concentration of five and zero-tenths (5.0) mg/l as a twenty-four (24) hour average** in water with WAH use;

b. **The instantaneous minimum shall not be less than four and zero-tenths (4.0) mg/l** in water with WAH use.

IV. Interpreting and Translating Narrative Standards to Develop Quantitative Targets

- Water quality standards that have words with no quantitative information must be **interpreted and translated**:
  - "eutrophication problems"
  - "objectionable color, turbidity"
  - "undesirable aquatic life"
  - "dominance of nuisance species"
  - "injure …or produce adverse physiological or behavioral responses in …fish, and other aquatic life"

IV. Interpreting and Translating Narrative Standards to Develop Quantitative Targets

- Some narrative standards includes impairments related to excess nutrients
  - excessive algal or plant growth
  - low concentrations or large fluxes of dissolved oxygen and pH
  - low biological integrity of aquatic communities

IV. Interpreting and Translating Narrative Standards to Develop Quantitative Targets

- Narrative standards must be **translated** to **numeric interpretations** using specific pollutant **indicators** when a **quantitative** goal or guideline is necessary.
- This is done on a case-by-case basis in the context of a **specific purpose** in a **specific place and time,** using the best available information.
- In this case, the **purpose** is to derive **nutrient targets for the TMDL model.**
- **These are targets developed for the TMDL model and should not be misconstrued as numeric nutrient criteria.**

IV. Interpreting and Translating Narrative Standards to Develop Quantitative Targets

Developing numeric targets for a TMDL involves:

- choosing one or more pollutant **indictors**
- determining appropriate **stratifications** and/or spatial **classifications** based on watershed characteristics
- identifying the appropriate **numeric standards** and/or identifying the approaches that will be used for **translating narrative** standards to **numeric interpretations**
- identifying or deriving model **targets** for each indicator with the following elements:
  - magnitude (how much, what level)
  - duration (on what time scale is it measured; averaging period)
  - frequency (how often are excursions allowed)

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- **Indicators:**
  - Dissolved Oxygen (DO)
    - numeric standard
  - pH
    - numeric standard
  - Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)
    - model target is numeric DO standard
  - Total Phosphorus (TP) and Total Nitrogen (TN)
    - No numeric standards
    - numeric interpretations of narrative standards to prevent nuisance benthic and suspended algae, and reduced biological integrity

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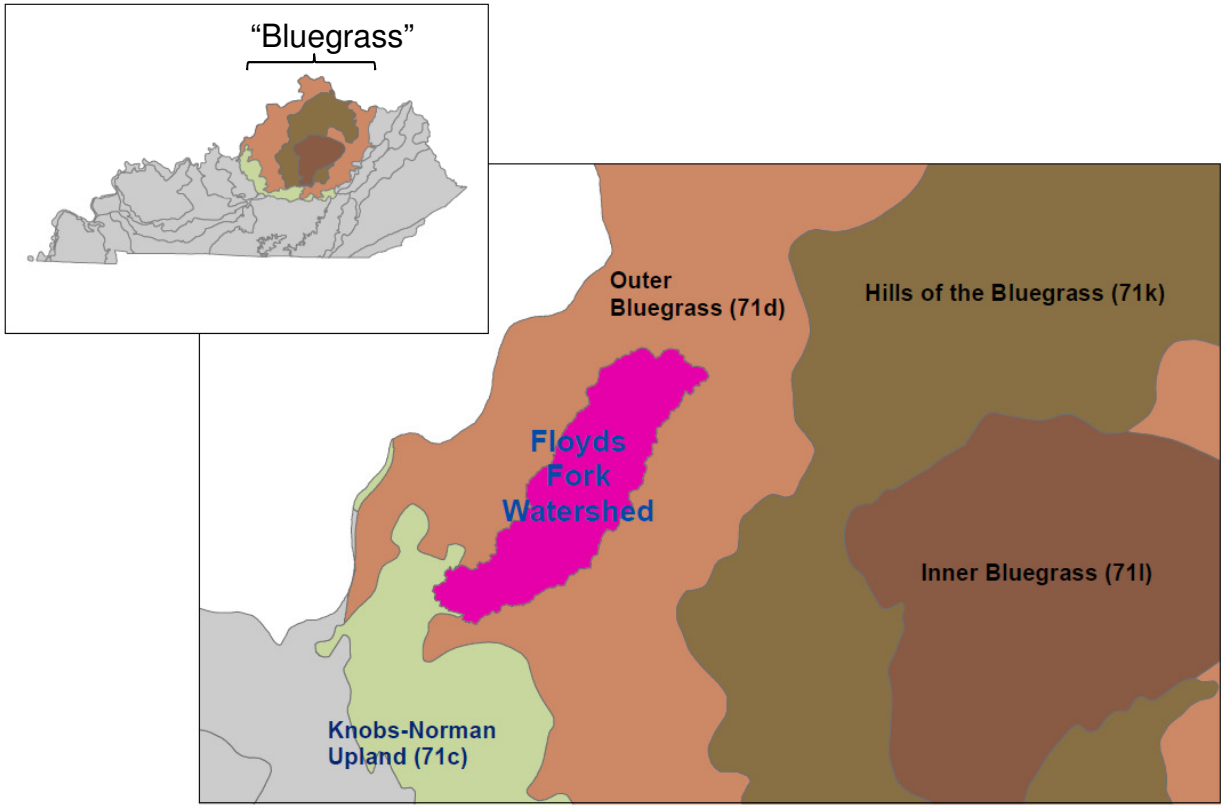
Watershed characteristics – regional setting



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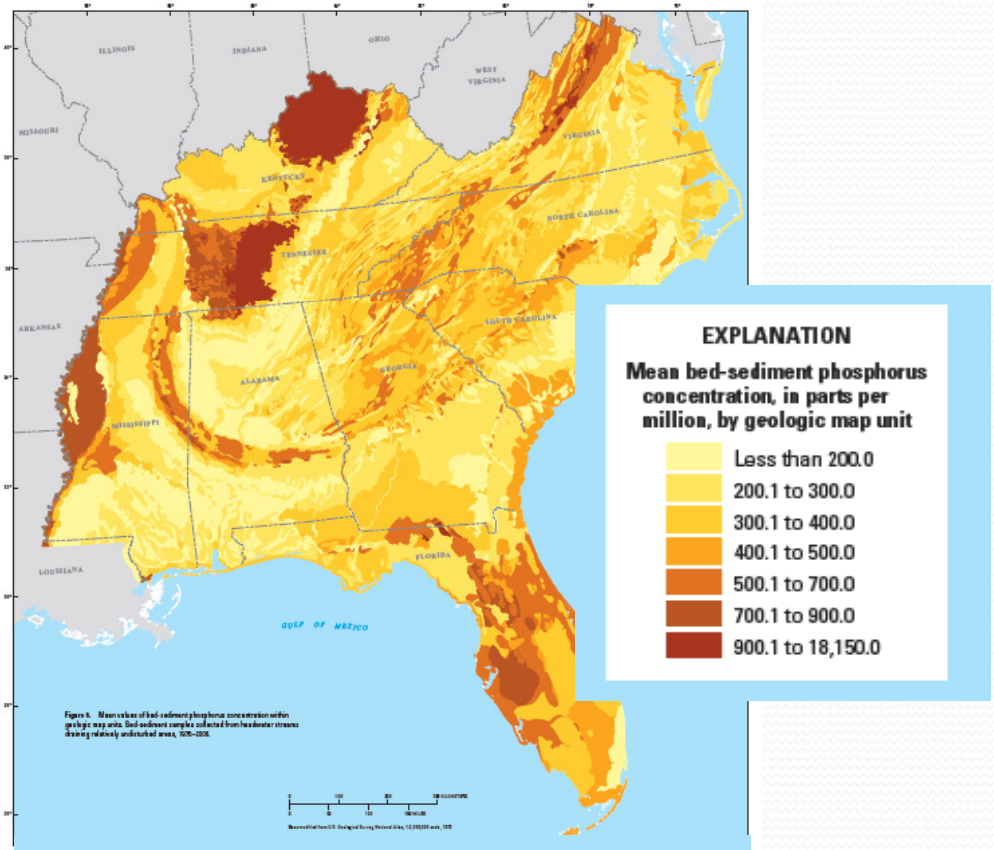

Figure 5. Mean values of bed-sediment phosphorus concentration within geologic map units. Bed-sediment samples collected from headwater streams draining relatively undisturbed areas, 1976–2006.

- The Bluegrass as a whole has substantial inputs of phosphorus from geologic sources
- There is considerable variation within and among the ecoregions that must be considered in setting expectations
- Data comparisons and analyses focused on Bluegrass only and/or ecoregion 71d specifically.

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Watershed characteristics – stream sizes

Ashers Run
2.8 mi^2

Chenoweth Run
17 mi^2

Floyds Fork @ Seatonville
172 mi^2

- depth
- canopy width
- flow regime
- substrate
- biota
- stream function

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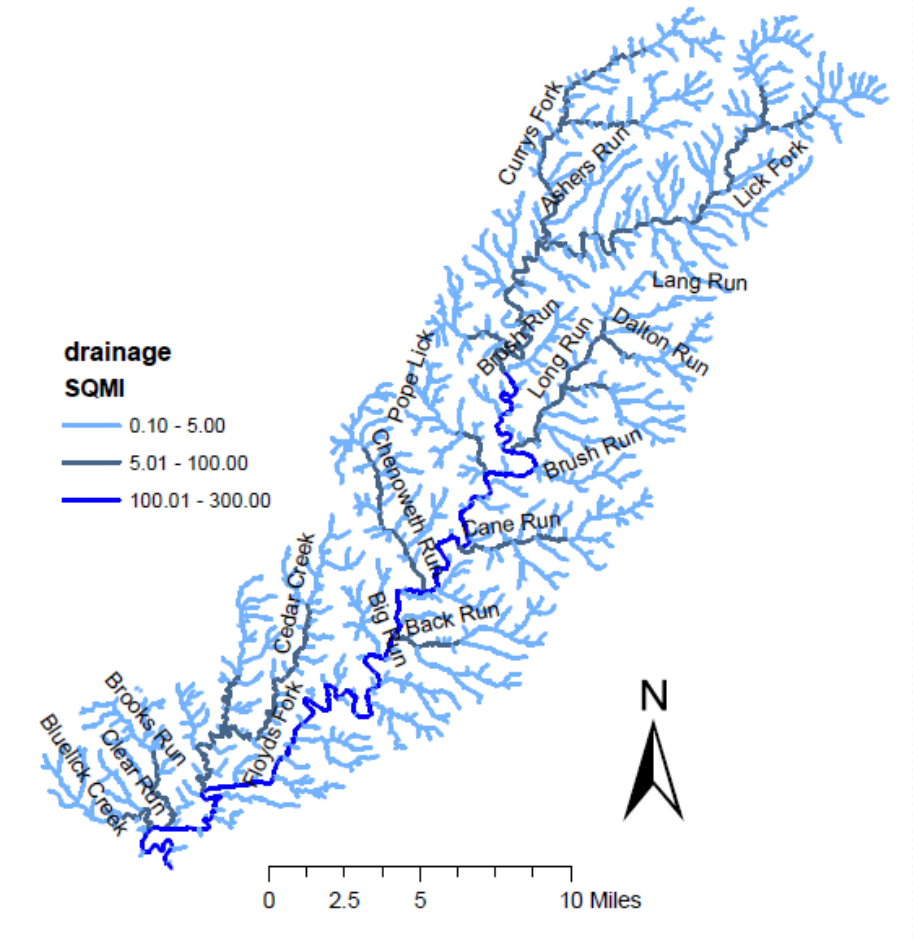
Stratification by stream size

Size Category	Catchment Area	Description
Headwater	<5 sq mi^2	Low or no summer-fall flow; distinct size category for biological indices; bioassessments in March-May
Wadeable*	5-100 mi^2	Year-round flow; biological assessments May-September
Transitional/ Boatable**	>100 mi^2	Long, slow, sunny pools during growing season; boating recreation important; biological assessments May-October

* includes tributaries in that size range and Floyds Fork mainstem above (Upper) Chenoweth Run

** includes mainstem of Floyds Fork downstream of (Upper) Chenoweth Run

V. Floyds Fork Nutrient TMDL Targets – Application of Stream Size



IV. Interpreting and Translating Narrative Standards to Develop Quantitative Targets

3 Approaches used to translate narrative standards to numeric targets:

- **empirical data** ("stressor-response")
  - at what concentration of a pollutant do healthy communities of aquatic life become impaired
  - effects should be those associated with the observed impairments
  - should be within the watershed or region for comparability
- **conditions at "reference sites"**
  - similar to the impaired sites; within watershed if possible
  - must have high level of confidence that the uses are supported
  - sufficient monitoring data to characterize conditions
- **literature thresholds or classification systems**
  - derived from comparable systems (region, size, etc)
  - classification systems should be relevant to the uses

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Model target elements for each size category:

- magnitude
  - specific to size class due to expectation of different effects
- duration
  - represented as an annual (headwaters) or growing season geometric mean (wadeable and transitional/boatable)
- frequency – 2 components
  - allow for infrequent excursions – once per 3 year period widely used as a general guideline to allow for ecosystem recovery
  - but set ceiling to prevent infrequent but large excursions that may have unpredictable/long-term impact

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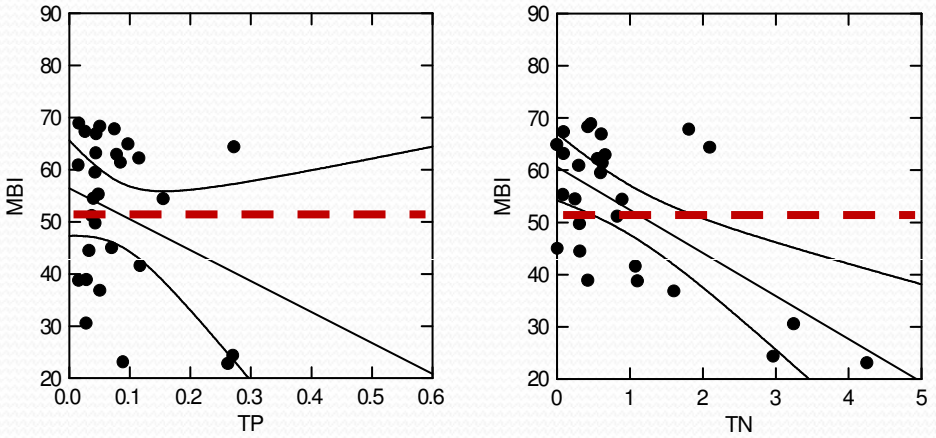
Headwater size class

- **empirical data** – not strong indication of well-defined thresholds, but evidence for reduced biological integrity in the range 0.8 – 1.5 mg/L TN



Relationship of Macroinvertebrate Bioassessment Index (MBI) scores with TN and TP, headwater Bluegrass streams; 90% confidence intervals on linear smoother.

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Headwater size class

- **reference site approach**
  - no appropriate reference sites within watershed or region with sufficiently frequent sampling
  - *alternative reference site analogue approach* using distribution of grab samples at all biologically healthy sites (71d ecoregion only, MBI ratings Good or Excellent)
  - 75th percentile used as conservative estimate of upper range in healthy sites

	TP mg/L	TN mg/L
N	8	8
maximum	0.157	0.909
75th percentile	0.085	0.638

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Headwater size class

- **literature**
  - widely cited recommendation of 0.100 mg/L TP to prevent nuisance algae is slightly above reference site candidate target
  - trophic classification (Dodds et al 1998): mesotrophic - eutrophic boundary 0.075 mg/L TP and oligotrophic-mesotrophic boundary 0.7 mg/L TN are near reference site candidate targets

	TP mg/L	TN mg/L
Oligotrophic	0.025	0.700
Mesotrophic	0.075	1.5

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Headwater size class

- **final targets**
  - 0.09 (0.12) mg/L TP
  - 0.7 (1.0) mg/L TN
  - to be applied as an **annual geometric mean**
  - not to exceed more than one in three years
  - number in parentheses is not to be exceeded in any year

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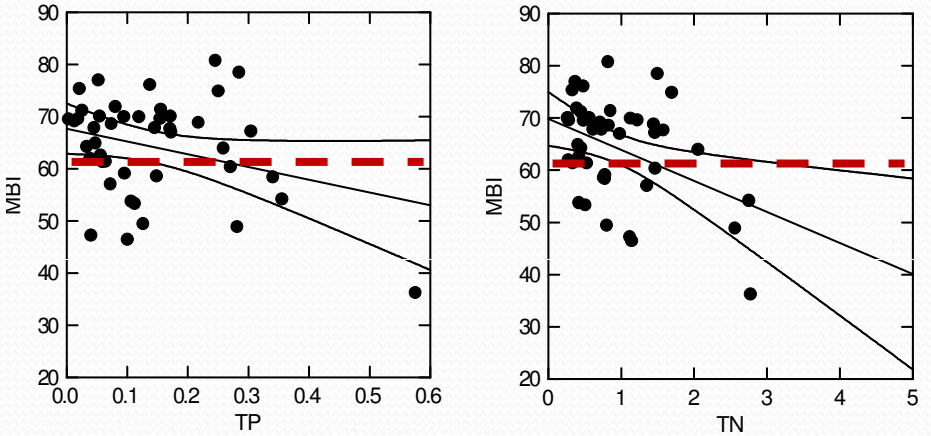
Wadeable size class

- **empirical data** – as with headwaters, considerable variability limits the ability to define a clear threshold, but biological Integrity does appear to decline in the range 0.1 - 0.3 mg/L TP and1 - 2 mg/L TN.



Relationship of Macroinvertebrate Bioassessment Index (MBI) scores with TN and TP, wadeable Bluegrass streams 90% confidence intervals on linear smoother.

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Wadeable size class

- **reference site approach**
  - no appropriate reference sites in watershed or region with sufficiently frequent sampling
  - *alternative reference site analogue approach* using distribution of all biologically healthy sites (71d ecoregion only, MBI ratings Good or Excellent)
  - 75th percentile used as conservative of upper range in healthy sites

	TP mg/L	TN mg/L
N	13	13
maximum	0.219	1.591
75th percentile	0.147	1.140

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- **literature**
  - published guidelines for nuisance algae prevention and trophic status generally are lower than reference site candidate targets, with the exception of the mesotrophic-eutrophic boundary for TN (1.5 mg/L).

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Wadeable size class

- **final targets**
  - 0.15 (0.25) mg/L TP
  - 1.1 (1.6) mg/L TN
  - to be applied at model as a **growing season geometric mean (April – October)**
  - not to exceed more than one in three years
  - number in parentheses is not to be exceeded in any year

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Transitional/Boatable Size Class

- **empirical data**
  - limited information available because of historically limited biological sampling at larger size streams

- **reference site approach**
  - watershed reference: Floyds Fork, RM 0 - 11.6
  - strong evidence of use support and 10+ years of water monitoring data
  - bioassessments (1999, 2004, 2011) showed Good or Excellent scores on fish and macroinvertebrate index
  - low suspended chlorophyll-*a* (max 8.5 µg/L chl-*a* from 5 summer samples 2010-2011)
  - minimal benthic algae mats (algae mats rarely reported during monthly or bi-monthly sampling visits 1999-2009)
  - Also utilized data from two comparable streams of same size, region and use support

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Monthly/ bimonthly samples – Growing season geometric means

Floyds Fork @ KY1526

Year	TP mg/L	TN mg/L
1999	0.159	1.359
2000	0.150	1.154
2001	0.133	1.194
2002	0.111	1.426
2003	0.185	1.434
2004	0.173	1.729
2005	0.158	2.191
2006	0.173	1.676
2007	0.198	1.848
2008	0.126	1.720
2009	0.174	1.768
min	0.111	1.154
max	**0.198**	**2.191**

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Monthly/ bimonthly samples – growing season geometric means

Brashears Creek @ Taylorsville

Beech Fork @ Maud 436 mi^2

	TP mg/L	TN mg/L
min	0.089	0.401
max	0.329	1.445

Brashears Creek @ Taylorsville 258 mi^2

	TP mg/L	TN mg/L
min	0.129	0.643
max	0.663	2.436

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Transitional/Boatable size class

- **final targets**
  - 0.20 (0.66) mg/L TP
  - 2.2 (2.4) mg/L TN
  - to be applied as a **growing season geometric mean**
  - not to exceed more than one in three years
  - number in parentheses is not to be exceeded in any year

V. Floyds Fork Nutrient TMDL Targets

TN and TP targets for model assessment points

Size category	TP target	TP max	TN target	TN max
Headwater (<5 sq mi^2)	0.09	0.12	0.70	1.0
Wadeable (5-100 mi^2)*	0.15	0.25	1.1	1.6
Transitional/Boatable (>100 mi2)**	0.20	0.66	2.2	2.4

* includes tributaries in that size range and Floyds Fork mainstem above (Upper) Chenoweth Run
** includes mainstem of Floyds Fork downstream of (Upper) Chenoweth Run

target: not to exceed as an annual (headwater) or growing season geometric mean more than once in a three year period
max: never to exceed as an annual (headwater) or growing season geometric mean

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- **Dissolved Oxygen from WQS**
  - instantaneous: ≥ 4.0 mg/L
  - 24 hr average: ≥ 5.0 mg/L
- **pH from WQS**
  - instantaneous: ≥ 7.0 and ≤ 9.0 units
  - 24 hr fluctuation: ≤ 1.0 unit
- **CBOD5 (Carbonaceous Biochemical Oxygen Demand)**
  - modeled to DO endpoint

VI. Monitoring Strategy for TMDL Target Validation

- planned biological sampling, field observations, and supplemental nutrient sampling to
  - verify previous assessments
  - confirm that model targets are appropriate
- 18 sites within Floyds Fork watershed, including likely unimpaired sites to be used as watershed reference, likely impaired sites, and sites with nutrients near target levels
- 4 external watershed reference sites in nearby watersheds

VI. Monitoring Strategy for TMDL Target Validation

- Monitoring outcomes to be reviewed by November 2012 in time to refine model targets if needed prior to finalizing TMDL

More Information:

- A detailed description of the development of nutrient targets for the TMDL is available upon request. Please contact FloydsFork@ky.gov for additional information.